CARAGANA ARBORESCENS LAM. FOR AFFORESTATION OF OIL SANDS RECLAMATION SITES: A REVIEW

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1. INTRODUCTION

1.1 Purpose

The Alberta Forest Service has questioned the use of Caragana arborescens Lam. (common names: caragana, Siberian peatree and Siberian peashrub; the common name caragana will be used throughout this report) as a high-portion species for afforestation of reclaimed areas associated with oil sands surface mines. Concern was expressed because caragana is not indigenous to North America and it is suspected that it may become aggressive and displace other planted native trees and shrubs (Bondy, 1982). Oil sands mining company officials indicated that caragana has a high survival rate and does well under the harsh conditions present on oil sands reclamation sites (Anderson, 1982). As a result of the concern expressed by the Alberta Forest Service, a review of the positive and negative contributions of caragana to oil sands reclamation sites was requested (Bondy, 1982).

This review will focus on answering the following questions:

- Where is caragana native?
- What is the natural habitat of caragana?
- What are the growth habits of this plant?
- What environmental conditions does caragana prefer?
- How does it interact with other plant species?
- How might it contribute to an anthropogenic forest ecosystem?
- How will wildlife make use of caragana?
- What are other possible uses of caragana?

Recommendations will be made based on the answers to the above questions. The answers will, it is hoped, assist government agencies and the oil sands mining companies in developing specific guidelines for use of caragana.

1.2 Information-Gathering Methods

The information in this report was gathered in two ways:

1. Appropriate scientific and extension literature from North America and Asia has been consulted. Due to the short time period in which this review was prepared, many promising reports could not be obtained in time to be reviewed.

2. The author made field observations of caragana plantings on reclamation sites on the leases of Syncrude and Suncor at Fort McMurray, Alberta. Older caragana plantings along the south-facing slopes of the North Saskatchewan River within the City of Edmonton were also observed. These observations are included in appropriate sections of this report.

2. CHARACTERISTICS

2.1 Origin and Geography

The only known monograph on the genus Caragana, by Kamarov (1908) indicates that there are 57 species (Moore, 1968). Allen and Allen (1981) have reported that 80 species of Caragana exist in the world. Caragana species originate from most areas of Eurasia, within an area from southern Russia to the Pacific coast and from the Himalayas and central China to 65 degrees north latitude (Moore, 1968). Caragana arborescens Lam. (caragana) is said to be indigenous to Siberia and Manchuria (Dietz and Slabaugh, 1974). Caragana was introduced into Europe and the United States in the mid-eighteenth century (Deitz and Slabaugh, 1974 and Moore, 1968). Knowles (1975) reported that caragana was introduced into Canada in the 1880s a shelterbelt and hedge plant.

2.2 Botany

Caragana is a deciduous, multiple-stemmed shrub or small tree which belongs to the pea or legume family (Leguminosae). It is said to be a slowly-growing (Carmean, 1976), long-lived (Anon, date unknown) species. Hermish (1982) suggested that caragana can grow for 80 years. In Alberta, it attains a height of five metres and a spread of one metre (Alberta Agriculture, undated). In Siberia, it is reported to grow to seven metres in height (Anon, 1945). The older wood has smooth, greenish-grey, shining bark (Photograph 1). The new shoots are slender, soft, and greenish or brownish. Leaves are compound and even-pinnate, with four to 12 leaflets, which are one to two centimetres long (Photograph 2). The leaves are grouped in fascicles on second-year wood and are borne singly on the present year's wood. The leaf axes have a bristle-like spine. The 15-to-23-millimetre, bright yellow, pealike flowers are grouped in fascicles of two to four

PHOTOGRAPH 1. Greenish-grey shining bark of a two-year-old Caragana arborescens twig.

PHOTOGRAPH 2. One-year-old leaves and twigs of Caragana arborescens.

on the previous year's wood and are borne singly on new wood. In Alberta, flowering commences in early June (Knowles, 1975) and flowering times in Russia are reported as May and June (Anon, 1945). The brown pods are four to five centimetres long and will split audibly to scatter brown seeds.

The following are sources of reference for the botany of caragana: Allen and Allen, 1981, Anon, 1945, Bailey, 1925, Bailey, 1976, Everett, 1960, Knowles, 1975, Moss, 1959, and Taylor, 1961.

2.3 Native Habitat

Moore (1968) stated that the genus Caragana occupies "a wide range of habitats: steppe, desert, dry rocky soils, both hot and frigid areas" and "at elevations to 12,000 ft." (3 600 metres). In its native Siberia and Manchuria, caragana is said to occur on riverbanks, in open forests and forest edges, on gully slopes and in rocky, sandy places (Anon, 1945).

2.4 Hardiness

Many authors have stated that plants in the genus Caragana exhibit hardy characteristics. Bailey (1925) indicated that all cultivated Caragana species, except a few Himalayan species, are "quite hardy". Cole (1980) has described caragana as "hardy" under Canadian conditions. Taylor (1961) stated that "few plants are superior in regions of intense cold". Caragana is found as far north as 61 degrees north latitude in its native Siberia (Anon, 1945).

Although caragana is said to be quite hardy, there is evidence which suggests that it can be damaged by frost, particularly in the first few years after establishment. Zalasky (1976) found that the thin-green bark of caragana is very susceptible to frost damage. He also indicated that the seedlings are intolerant to frost-heaving.

2.5 Drought Resistance

Numerous authors have described caragana as a species that will survive well on dry, arid sites (Alberta Agriculture, 1978, Cole, 1980, Everett, 1960, George, 1936, Head, 1964, Hildreth, 1951, Knowles, 1975, Mayer-Wegelin, 1943, and Zalasky, 1976). Alberta Agriculture (1978) recommends caragana for "soils which have prolonged periods of drought". Everett (1960) claims that caragana was "suitable for planting on dry banks". A report by George (1936) indicated that on the northern great plains, where precipitation averaged 15 inches (38 centimetres) per year, seven out of 22 planted trees and shrubs grew and survived satisfactorily. One of the seven was caragana. Knowles (1975) stated that caragana species "are particularly suited to dry situations and will thrive under the low rainfall conditions of most areas without artificial watering". Zalasky (1976) stated that excessive moisture was one of the major reasons for loss of caragana at Indian Head, Saskatchewan.

On August 19, 1982, the author of this report observed caragana plantations on sand dykes at both the Syncrude and Suncor oil sands strip-mines near Fort McMurray, Alberta. It was noted that while caragana may survive the dry conditions present on the dykes, it thrives when some moisture is available. Caragana growing on the downward edge of a dyke terrace at Syncrude where moisture was present was estimated to be two to three times the height of similar-aged caragana growing down the dyke in an obviously dry location. Similar situations were observed on Suncor's sand dykes.

It is clearly seen from the literature that caragana is tolerant of dry, arid conditions and intolerant of excessive moisture. However, extremes in moisture deficiency will result in slower growth, as was evident on the sand dykes at Fort McMurray.

2.6 Soil Preference

Experimental work undertaken by Carmean (1976) in western Minnesota indicated that caragana grew well on light, medium, and heavy soils. Caragana and two other species (Russian Olive (Elaeagnus angustifolia) and Green Ash (Fraxinus pennsylvanica)) were evaluated on sandy loam, loam and silty clay loam. Three sizes of caragana planting stock, 9.8 (24.9), 16.8 (42.7), and 33.8 (85.8) inches (centimetres), survived very well on all three soil types.

Cole (1980) suggested that caragana could be planted on heavy to light soils and be expected to succeed. Dietz and Slabaugh (1974) stated that "Caragana readily adapts to sandy, alkaline soil" on the northern great plains. Everett (1960) indicated that "These hardy shrubs (caragana) thrive best ... in light, well-drained, rather sandy soil".

Other authors have offered similar opinions regarding caragana's preference for light, sandy soil. Caragana will grow on a wide range of soils but it appears to prefer light, sandy soils.

2.7 pH Sensitivity

Carpenter and Hensley (1979) worked with caragana and a number of other shrub and tree species on distressed or disturbed soils with low pH. He found that caragana was more sensitive to low pH than were the other species. Survival of caragana during the first month after planting in soils with a pH of 2.8 was approximately 20 percent, compared with the survival of other woody species, which ranged from approximately 50 to more than 90 percent. After the first, month survival of all species declined at this low pH level. Survival of caragana at a pH of approximately 5.0 was 15 to 20 percent lower than the rate of survival of caragana at a pH of 6.5. Caragana was not among the woody species Carpenter and Hensley recommended for harsh, low-pH soil conditions.

2.8 Light Requirements

Anon (1945) has indicated that the preferred natural habitat of caragana in Siberia and Manchuria is open forests and the edges of forest. This evidence, which suggests that caragana likes sunny positions, is supported by other authors. In Bailey's Hortus Third (1976) it is stated that caragana "should be planted in sunny locations". Dietz and Slabaugh (1974) observed that caragana readily adapts to "open, unshaded sites on the northern Great Plains". Everett (1960) and Seymour (1951) also suggest its use in "sunny places".

Experimental results obtained by Cram and Lindquist (1963) at Indian Head, Saskatchewan showed that caragana grew continuously under both short (3.7 hours per day) and long (16 hours per day) photoperiods with the most rapid growth under the long photoperiod. Colorado Spruce (Picea pungens) and Scots Pine (Pinus sylvestris) terminated growth under photoperiods of eight and ten hours per day and grew only when light was provided for 16 hours per day.

It appears that caragana prefers sunny, open locations but will, in fact, continue to grow (at a slower rate) under a reduced photoperiod.

2.9 Competitiveness

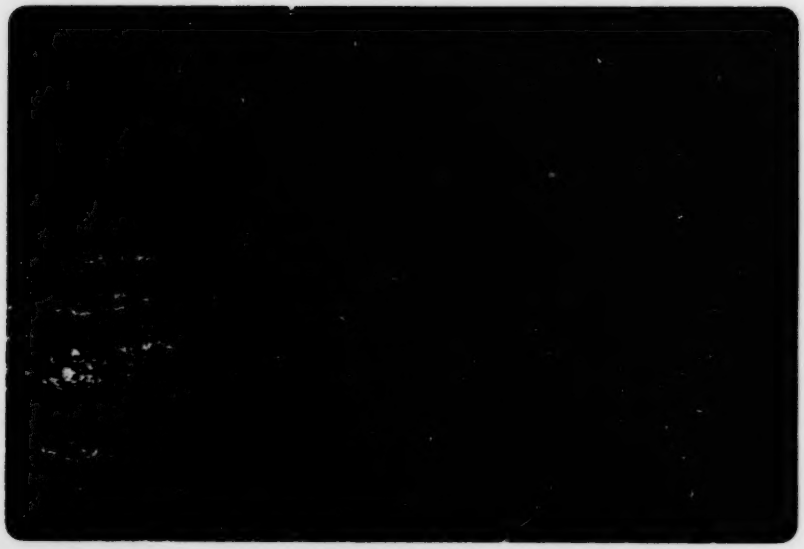
The literature suggests that caragana is competitive. Knowles (1975) stated that it is "strongly competitive when planted with other material" in the prairie provinces. Both Moss (1959) and Scoggan (1978) have noted that caragana has escaped cultivation in places and spread to open woods and clearings in Alberta. Under dry conditions in the U.S.S.R., Afanas'eva (1958) wrote that "C. arborescens is a dangerous competitor for moisture".

In a study of caragana planted in the Ukraine as early as 1843, Mayer-Wegelin (1943) noted that, under dry conditions, this shrub was effective in suppressing competing vegetation, but did not tend to

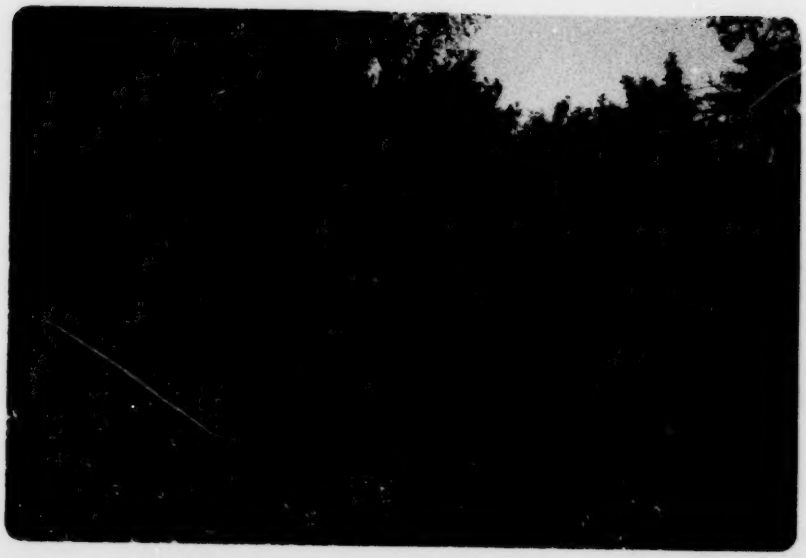
suppress oaks and other trees. Shebalov (1970) supported Mayer-Wegelin in his observations of caragana growing with larch and pine in Russia. He observed "Caragana arborescens planted in rows between the rows of larch on dark gray forest soils with a stable water regime is conducive to the growth of larch and pine".

Zolotukhin (1980), working in the U.S.S.R., provided some evidence that caragana exhibits allelopathic affects. Anderson (1977) describes allelopathy as the "release of toxic or growth-inhibiting substances into the soil as root exudates and/or leachates of their dead and decaying vegetative matter, thereby reducing or eliminating the competitiveness of" other plants. Zolotukhin stated that "The herbaceous cover developed poorly under the Caragana arborescens; in areas where the undergrowth (caragana) was absent, repens and narrow-leaved meadow-grass, which make up the turf, grew vigorously". Phenol compounds were drained from under caragana and other shrub species in laboratory experiments. These compounds may disturb the growth of A. repens (couch grass) according to Zolotukhin.

Support for the possible allelopathic behaviour of caragana was gained by the author of this report in observing 25-year-old plantations on the south-facing slopes of the North Saskatchewan River in the city of Edmonton. Under several stands of solid caragana, at a site immediately south of the Provincial Museum (128 Street and 102 Avenue), there were few or no grasses or forbs growing (Photograph 3). The leaf and pod litter has attained a depth on the ground of up to 12 centimetres. At the same site and in other areas, such as along Groat Road, other trees and shrubs such as trembling aspen (Populus tremuloides), balsam poplar (Populus balsamifera), lilac (Syringa spp.), chokecherry (Prunus pensylvanica), saskatoon (Amelanchier alnifolia) and green ash (Fraxinus pennsylvanica) were growing and competing well with caragana (Photograph 4). Nyroos (1982) of the City of Edmonton's Forestry Department feels that caragana is highly compatible with other trees and shrubs. The city is continuing to plant caragana as a component species in areas requiring afforestation and slope stabilization.



PHOTOGRAPH 3. Lack of herbaceous growth under a solid 25-year-old plantation of Caragana arborescens on a south-facing slope of the North Saskatchewan River in the City of Edmonton just south of the Provincial Museum at 128 Street and 102 Avenue.



PHOTOGRAPH 4. Caragana arborescens growing in harmony with other trees and shrubs along Groat Road in the City of Edmonton.

The caragana observed on the North Saskatchewan River banks did not appear to be invading any adjacent grassy area to a significant degree after more than 25 years. Caragana suckers appear to arise from the crown of the plant, which results in a multiple-stemmed shrub. Some seedling growth was noted among dense grass adjacent to some caragana stands. Nyroos (1982) feels that grass growing vigorously beside caragana is possibly obtaining nitrogen from the nitrogen-fixing root nodules of caragana.

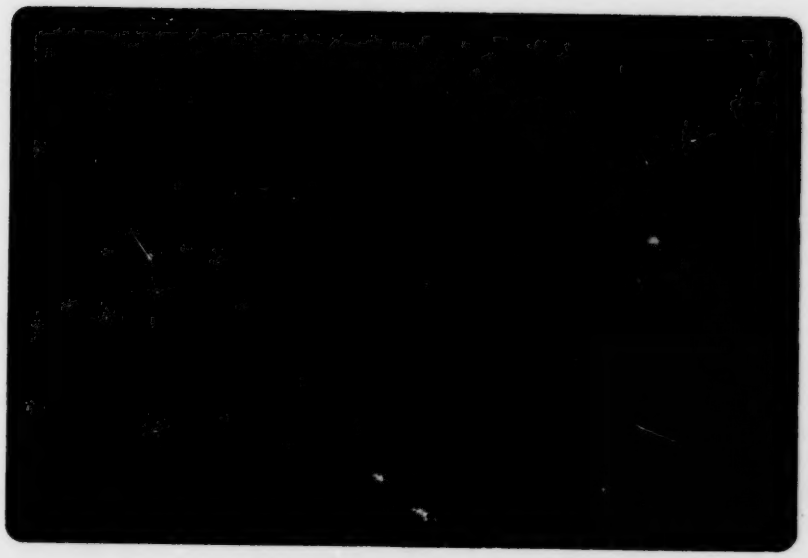
Five-year-old caragana plantations on reclamation sites at Syncrude's oil sands lease near Fort McMurray, Alberta, did not appear to cause any grass growth reduction. Grass growth was healthy and vigorous under these plantations (Photograph 5).

Some evidence of the competitiveness of caragana was observed on Suncor's lease. Numerous seedlings had become established around mature parent plants in an older plantation on one of the dykes (Photograph 8).

2.10 Nitrogen Fixation

Nitrogen fixation refers to the symbiotic association between root-nodule bacteria of the genus Rhizobium and, most often, leguminous plants. This association results in the fixation of atmospheric nitrogen into nitrogen compounds, which can be utilized by plants (Allen, 1974). Rhizobia was isolated from caragana as early as 1888 (Allen and Allen, 1981). Gregory and Allen (1953) worked with 14 strains of rhizobia from caragana, all of which "belonged to the slow-growing cowpea-soybean-lupine type of rhizobia" (Allen and Allen, 1981). Using acetylene-reduction-assay methods to determine the nitrogen-fixation activities of a number of shrubs, McNiel and Carpenter (1974) determined that caragana, as well as a number of other woody plants, do fix nitrogen.

Allen and Allen (1981) made the following comments about the nitrogen-fixing ability of caragana:



PHOTOGRAPH 5. Healthy herbaceous vegetation under a five-year-old Caragana arborescens plantation on Syncrude's oil sands lease at Fort McMurray, Alberta.

> Caragana nodules are among the few perennial types that have been studied histologically...
>
> Throughout the life of a Caragana nodule the volume of tissue functionally active in nitrogen fixation remains more or less constant...

In addition, work done by McNiel and Carpenter (1974) indicated that the nitrogen-fixing activities of caragana are similar to a number of other woody, nitrogen-fixing plants.

2.11 Wildlife Use

A number of reports state that caragana is utilized by both birds and mammals. Anon (1945) reported that "The seeds contain 12.4% fatty oil and are used as bird food" in the U.S.S.R. In North America, Allen and Allen (1981) indicated that "The seeds are food for wildlife". Anon (date unknown) stated that "It [caragana] is used for nesting by several songbirds, including willow fly-catcher, yellow warbler, yellowthroat, clay-coloured sparrow and song sparrow. The seeds are occasionally eaten by a few songbirds and gray partridge".

Evidence of birds using caragana was noted by the author of this report during a recent trip to Suncor's oil sands lease at Fort McMurray, Alberta. A bird's nest was noted in a five-year-old caragana shrub on one of the sand dykes (Photograph 6). The species of bird nesting in the caragana shrub was not determined.

There is evidence of caragana being utilized by browsing animals. Fourteen-year-old caragana was evaluated by Messner and Uresk (1980) as a winter browse species for white-tailed deer in western South Dakota. Their findings are as follows:

> Volume of the shrubs (caragana) decreased 77% by deer utilization through the winter months and was highest on south facing slopes. Overall survival after 12 years was 74%. The results indicate that

PHOTOGRAPH 6. A bird's nest on a five-year-old Caragana arborescens shrub growing on one of Suncor's sand dykes at Fort McMurray, Alberta.

> caragana is a suitable winter browse species for white-tailed deer in the ponderosa pine type of western South Dakota.

Dietz and Slabough (1974) supported Messner's and Uresk's finding when they observed extensive browsing of caragana by deer and suggested that caragana shows promise for deer-range revegetation programs in the Black Hills of South Dakota.

Allen and Allen (1981) quoted Roizin (1959) as having indicated that caragana is used "as supplementary food for the maintenance of reindeer herds within the Arctic Circle on the Kola Peninsula" of the U.S.S.R.

One report suggests that "This plant (caragana) is not a preferred food for browsing animals" (Anon, date unknown). It may be that if preferred woody browse species are available, animals may make less use of caragana. It is obvious from the literature, however, that caragana is utilized by at least some browsing animals and that caragana is used by birds for nesting and for food.

3. USES

3.1 Indigenous Areas

Caragana is especially prized as an ornamental, hedge, and windbreak plant in its native Siberia (Anon, 1945). It is reported by Mayer-Wegelin (1943) that "More than 100,000 ha of windbreaks (shelterbelts) were planted in the Ukraine during the 10 yrs. preceding the war". This author further reported that caragana was extensively planted for shelterbelts as early as the fifteenth century in the Ukraine.

Anon (1945) reported that caragana is used in afforestation in the south of the U.S.S.R. Mayer-Wegelin (1943) and Shebalov (1970) indicated that this plant is used as a nurse plant in afforestation and reforestation to protect oak, birch and pine while they are establishing in cold and/or dry areas.

Many other uses are also reported for caragana in its indigenous area (Allen and Allen, 1981 and Anon, 1945). The leaves contain a blue dye which is extracted for various uses. The best fibers of caragana shoots are used for rope making. Caragana is used as a soil improvement plant in agriculture. The young pods or sometimes eaten as a vegetable and in years of famine the seeds are used for human food. Bees utilize the flowers in honey making. An interesting report by Zizin (1947) indicated that "Peas, beans, lentils, and other leguminous plants were successfully grafted... upon Caragana arborescens, whose frost and drought-resistance was thus utilized".

3.2 North America

Caranaga "is the most widely planted shrub species in the northern Great Plains" of the United States and Canada (Anon, date unknown). It

is used little in the southern United States as its growth vigor decreases south of Nebraska (Allen and Allen, 1981). It is recommended for planting on the outward or windward side of multi-row shelterbelts or it can be used as a single row windbreak. Seymour (1951) maintained that caragana "is one of the best hedge and shelter plants for the prairies of the Northwest". Moore (1968) suggested that caragana "has become of great economic value in North America as a shelterbelt shrub of the Prairies of both Canada and the Unitied States". Cram (1969) claimed that caragana "has proven to be one of the more valuable and most versatile species of trees for shelterbelt plantings in the Canadian prairies over a period of 60 years". Bailey (1925 and 1976) reported that it is also grown as an ornamental for its showy flowers.

Alberta Agriculture (1978) recommends caragana for planting on the exposed sides of shelterbelts for maximum effectiveness in providing protection to farmsteads, to prevent soil erosion by wind and to protect roads from snow drifting. Caragana has also been used for erosion control on steep slopes such as the North Saskatchewan River banks in the City of Edmonton (Nyroos, 1982).

The Alberta Tree Nursery at Oliver which is operated by Alberta Agriculture supplies large quantities of caragana seedlings to farmers and acreage holders each year. For example, in 1973, 668 000 caragana seedlings, which represented 41.4 percent of all trees and shrubs, were provided for hedge and shelterbelt purposes (Alberta Agriculture, 1973). The total is up in 1981 to 1 058 000 caragana seedling which represented 37.8 percent of all trees and shrubs shipped (Alberta Agriculture, 1981).

The slight reduction in the above percent-shipped figures which is evident from 1973 to 1981 would seem to indicate that caragana is losing its popularity. This information is supported by Knowles (1975) who suggested that caragana's "popularity has been on the wave". It is still evident; however, that this hardy, drought-resistant plant is still very popular as a hedge and shelterbelt plant on the northern Great Plains of North America.

3.3 Oil Sands Afforestation

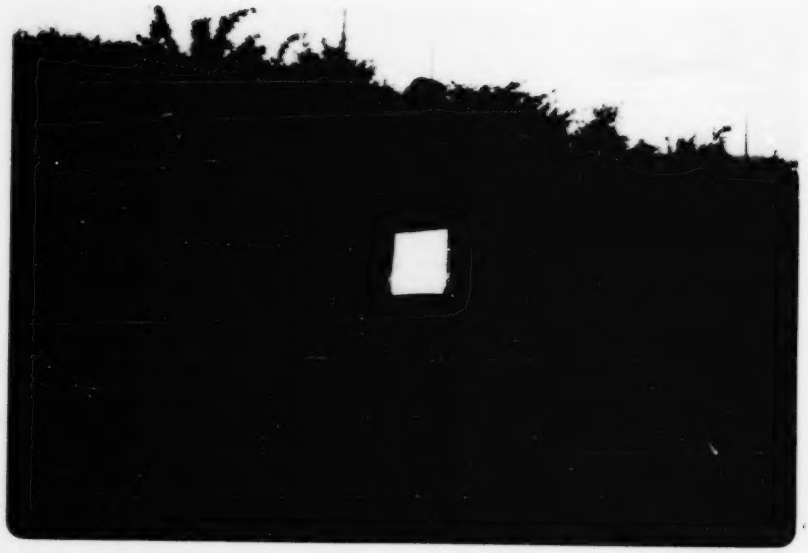
Caragana is being used by the Alberta oil sands mining companies, Syncrude Canada Limited and Suncor Inc., in afforestation experiments and programs on tailing-pond dykes, recontoured mined-out areas and construction sites reclamation (Photographs 7 and 8). Tables 1 and 2 relate caragana planted each year to the total number of trees and shrubs planted in each year.

Survival of caragana on the tailings-pond dykes and other areas has generally been considered good at both Suncor and Syncrude. Shopik (1980) reported that "Initial survival was best for caragana, northwest and walker poplars, chokecherry, basford and acute willows and dogwood." The average 1980 survival rate of caragana from four treatments set out by Suncor in 1979 was higher than for all other trees and shrubs planted in the same four treatments (Klym, 1981). In this trial, 84.0 percent of the caragana survived, while the survival rate of the other trees and shrubs ranged from 33.7 to 69.5 percent.

Dai and Langevin (1978) reported that the survival rate of caragana planted at Syncrude's lease on a dry, south-facing slope at Poplar Creek in 1977 was 48.4 percent, which was the third-highest survival rate of the eight species of trees and shrubs assessed. In 1978 and 1979, the survival rate of caragana dropped considerably, to five and three percent respectively, on this dry site. The survival rates of other trees and shrubs dropped correspondingly -- zero and 10 percent for balsam poplar and american elm (Ulmus americana) respectively.

Survival of all trees and shrubs on a northeast-facing dyke slope at Syncrude was much improved compared with survival at the dry Poplar Creek site. One year after planting, caragana's survival rate was 86.4 percent compared with the survival rate of low bush cranberry (Viburnum edule) which was 28.4 percent, and the high survival rate of green alder (Alnus crispa), which was 97.5 percent (Anderson, 1980). The vigour rating for caragana was average compared with that of the other

PHOTOGRAPH 7. A 30 percent Caragana arborescens plantation three years after establishment on one of Syncrude's sand dykes.



PHOTOGRAPH 8. A ten-year-old Caragana arborescens plantation with new seedlings on one of Suncor's sand dykes.

TABLE 1

Suncor Afforestation Statistics (Shopik, 1982)

YEARS	CARAGANA	EXPERIMENTAL OR OPERATIONAL	TOTAL TREES & SHRUBS
1971	0		300
1972	1 300	Exp.	5 600
1973	0		1 000
1974	0		2 300
1975	0		4 000
1976	0		9 300
1977	3 800	Exp.	18 000
1978	0		17 000
1979	6 500	Exp.	29 000
1980	0		44 700
1981	0		74 700
1982	0		78 000

TABLE 2

Syncrude Afforestation Statistics (Anderson, 1982)

YEARS	CARAGANA	EXPERIMENTAL OR OPERATIONAL	TOTAL TREES & SHRUBS
1977	11 657		46 300
1978	7 458		42 200
1979	4 390		18 000
1980	0		92 000
1981	32 100	Op (60 Exp)	87 600
1982	58 863	Op (120 Exp)	299 700

trees and shrubs. The 1980 assessment of this same 1978 plantation showed that the caragana survival rate of 37.8 percent was higher than that of any other tree or shrub. An assessment of the 1979 planting revealed that again, the caragana survival rate of 78.1 percent was higher than that of all other trees and shrubs planted in that same year on the north starter dyke slope.

Mouse damage reported by Langevin (1980) two years after the 1977 caragana planting was 2.8 percent on the northeast-facing oil sands slope. Comparative data for other trees and shrubs was not available in this report; however, it is assumed that 2.8 percent mouse damage is light.

4. SUMMARY

The following point-form summary will give the reader a brief review of the foregoing information.

Caragana:

- is indigenous to Siberia and Manchuria where it grows as far north as 61 degrees north latitude.
- is a slowly-growing, long-living shrub or small tree which is a member of the legume or pea family (leguminosae).
- occurs naturally on riverbanks, in open forest, on forest edges and other open, sandy, rocky places.
- is very winter-hardy, but may sustain some frost damage in the first few years after establishment.
- survives well on dry, arid areas but it will grow vigorously on moist, well-drained soil.
- will do poorly on sites with excessive moisture.
- grows well on a wide range of soil types (clay to sand) but prefers light, sandy soil.
- will adapt readily to alkaline soils.
- may not do as well as other tree and shrub species on soil of lower-than-normal pH.
- prefers sunny locations in open areas or on the forest edges.
- is competitive with herbaceous vegetation.
- may display allelopathic effects whereby herbaceous growth may be restricted or eliminated under dense, older stands.
- exists well with other trees and shrubs.
- does not spread by underground suckers in a manner similar to that of trembling aspen, but does sucker from the crown to form a multiple- stemmed shrub.
- does spread into adjacent grassy areas by seedlings.
- is a nitrogen-fixing legume associated with the common Rhizobia

strains and produces amounts of nitrogen similar to those of other woody nitrogen-fixers.

- seed is a good food-source for birds and the shrubs provide nesting sites for a number of bird species.

- is utilized by some browsing animals but may not be preferred over other available browse.

- has numerous uses in its native Siberia and Manchuria including uses as windbreaks, ornamentals, nurse plants in afforestation and reforestation, dye from the leaves, rope making, soil improvement, bird and wildlife food, human food, honey production and graft-host plant for other, less hardy legumes.

- is used in North America, mainly on the northern great plains for the windward side of shelterbelts, as single-row hedges, as an ornamental, in erosion control, and on oil sands reclamation sites at Fort McMurray, Alberta.

5. DISCUSSION

It is not the purpose of this paper to determine whether non-native trees and shrubs should form a component of the final vegetation ecosystem on oil sands reclamation sites; however, because caragana is not native, a few comments would seem in order before further evaluating this plant.

Oil sands reclamation sites which are being revegetated are drastically-altered sites which will not likely be the same as they were before the mining operation, even if considerable expense and effort were put in that direction. In fact, land-use managers may purposely create an anthropogenic ecosystem quite different from the original. This ecosystem would be designed to meet specific land-use objectives, for example, timber production, wildlife use or recreational use. In the selection of plant species to meet the predetermined objectives, the selection should be based on the individual characteristic of each species. It would, therefore, seem in order to select non-native plants as long as they have the desired characteristics.

The desirable characteristics of caragana are that it is winter-hardy, drought-resistant, prefers sandy soil, fixes nitrogen, is used by birds for food and nesting, is browsed by wildlife, can be used as a nurse plant to protect other establishing trees and shrubs, and does not appear to be overly competitive with other trees and shrubs.

The undesirable characteristics of caragana are that it may in the long term reduce or eliminate grasses and forbs growing underneath solid stands and it spreads rapidly by seedlings, even in dense grass. Caragana may eventually form solid stands if no other trees and shrubs

are present. It must be kept in mind that caragana is a sun-loving plant and that a canopy of other trees and shrubs may reduce or eliminate its spread by seedlings.

6. RECOMMENDATIONS

Caragana is well suited to the environmental conditions present on most of the oil sands reclamation sites. It is, therefore, the recommendation of the author of this report that caragana continue to be used in afforestation on the oil sands as long as the following conditions are met.

1. Caragana should always be mixed with other tree and shrub species and never exceed 25 percent of the plantation in the planting year.

2. In years subsequent to the planting year, caragana should never be allowed to exceed 50 percent of the plantation. Survival of caragana is likely to be higher than that of other trees and shrubs; therefore, replacement stock, other than caragana, must be reintroduced into the plantation to maintain the balance. Solid or high-proportion stands of caragana may, in the long term, cause a reduction in grass and forb cover, and erosion may result.

3. Caragana should be used whenever possible as an edge planting, particularly on the windward side of the plantation, to provide protection for other establishing trees and shrubs. It is anticipated that caragana will eventually become well established along the edges, but it will gradually be shaded out by the canopy of taller trees. It must be kept in mind that caragana in its natural habitat is a edge plant and grows well in sunny locations.

4. Caragana could be planted in alternating rows with other trees and shrubs. For example, every fourth row could be caragana. In this way, caragana may provide some protection to other establishing shrubs and trees.

5. On particularly harsh sites, caragana may initially be planted without other trees and shrubs. After it becomes established

and can act as a buffer, other trees and shrubs should be introduced. Caragana may ameliorate harsh sites by: trapping snow; providing litter which will reduce soil moisture loss; providing shade, which will reduce moisture loss; and stabilize slopes.

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